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Myoga et al.

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(54) **IMAGE PROCESSING APPARATUS, METHOD THEREOF AND PROGRAM THEREFOR**

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H04N 9/64 (2006.01)
H04N 9/04 (2006.01)
H04N 5/217 (2011.01)

(52) **U.S. Cl.**
CPC ***H04N 9/646*** (2013.01); ***H04N 5/2175*** (2013.01); ***H04N 9/045*** (2013.01)

(58) **Field of Classification Search**
CPC H04N 9/646; H04N 9/045; H04N 5/2175; H04N 5/21; G02B 5/201; G02B 27/60; G05B 2219/37131
USPC 348/242
See application file for complete search history.

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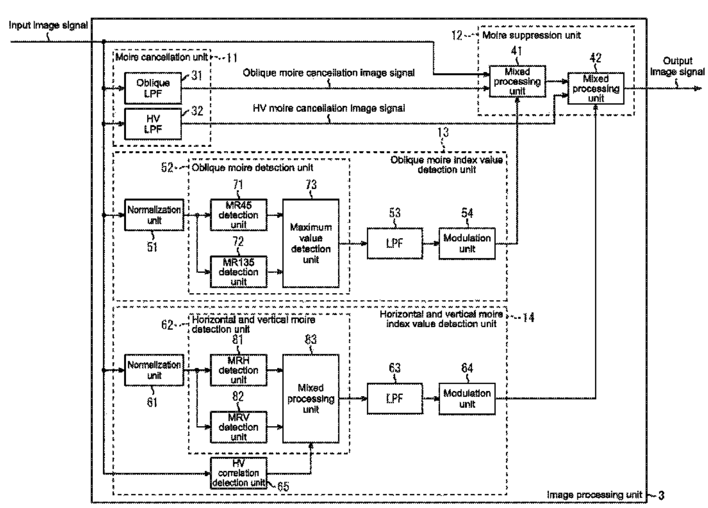
(57) **ABSTRACT**

An image processing apparatus includes a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array; a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and a moire suppression unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit. A method thereof and a program therefor are also provided.

11 Claims, 12 Drawing Sheets



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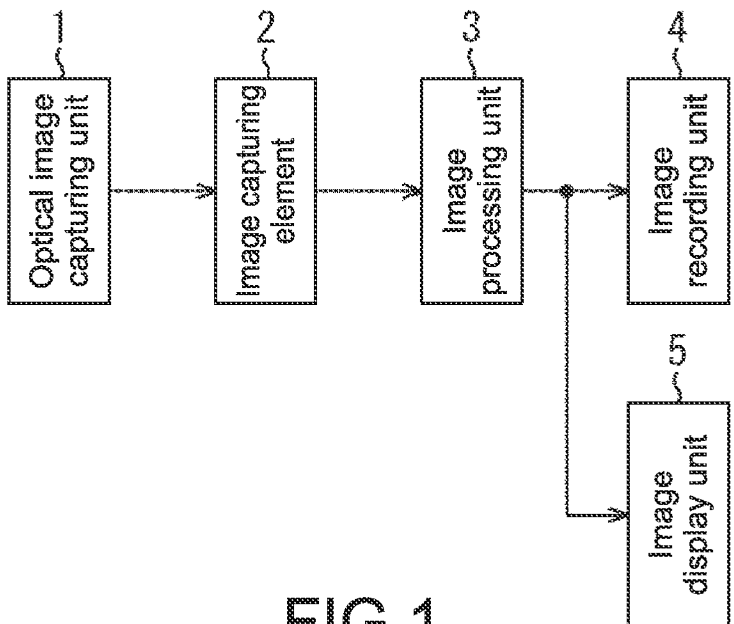
1
Optical image capturing unit
2
Image capturing element
3
Image processing unit
4
Image recording unit
5
Image display unit

FIG.1

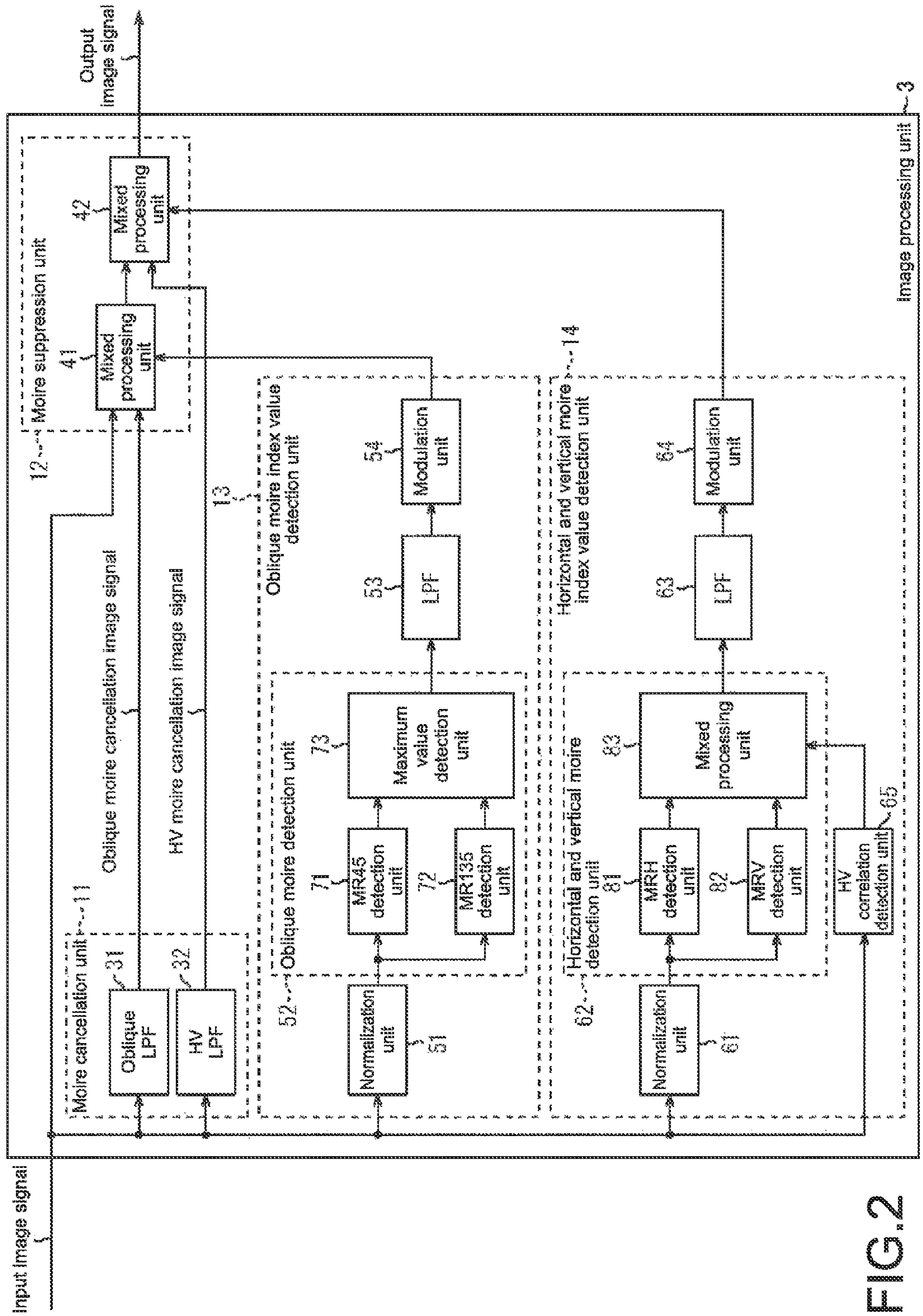
Input image signal
Output image signal
Image processing unit
3
Moire cancellation unit
11
Oblique LPF
31
HV LPF
32
Oblique moire cancellation image signal
HV moire cancellation image signal
Moire suppression unit
12
Mixed processing unit
41
Mixed processing unit
42
Oblique moire index value detection unit
13
Normalization unit
51
Oblique moire detection unit
52
MR45 detection unit
71
MR135 detection unit
72
Maximum value detection unit
73
LPF
53
Modulation unit
54
Horizontal and vertical moire index value detection unit
14
Normalization unit
61
Horizontal and vertical moire detection unit
62
MRH detection unit
81
MRV detection unit
82
Mixed processing unit
83
HV correlation detection unit
65
LPF
63
Modulation unit
64

FIG.2

0	1	0
1	4	1
0	1	0

1	0	1
0	4	0
1	0	1

FIG.3

1	−2	1
−2	4	−2
1	−2	1

1	1	1
1	1	1
1	1	1

FIG.4

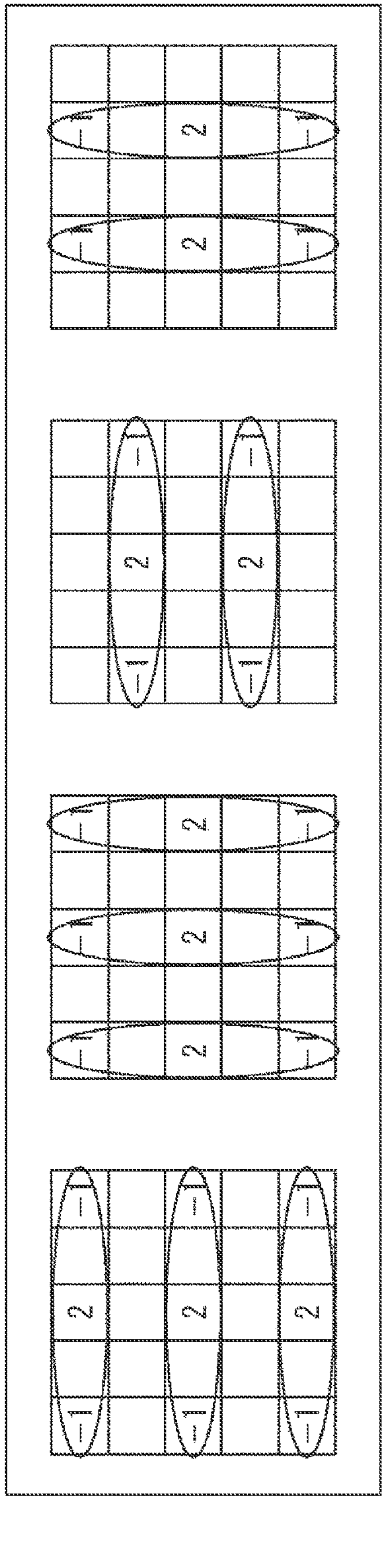

FIG.5

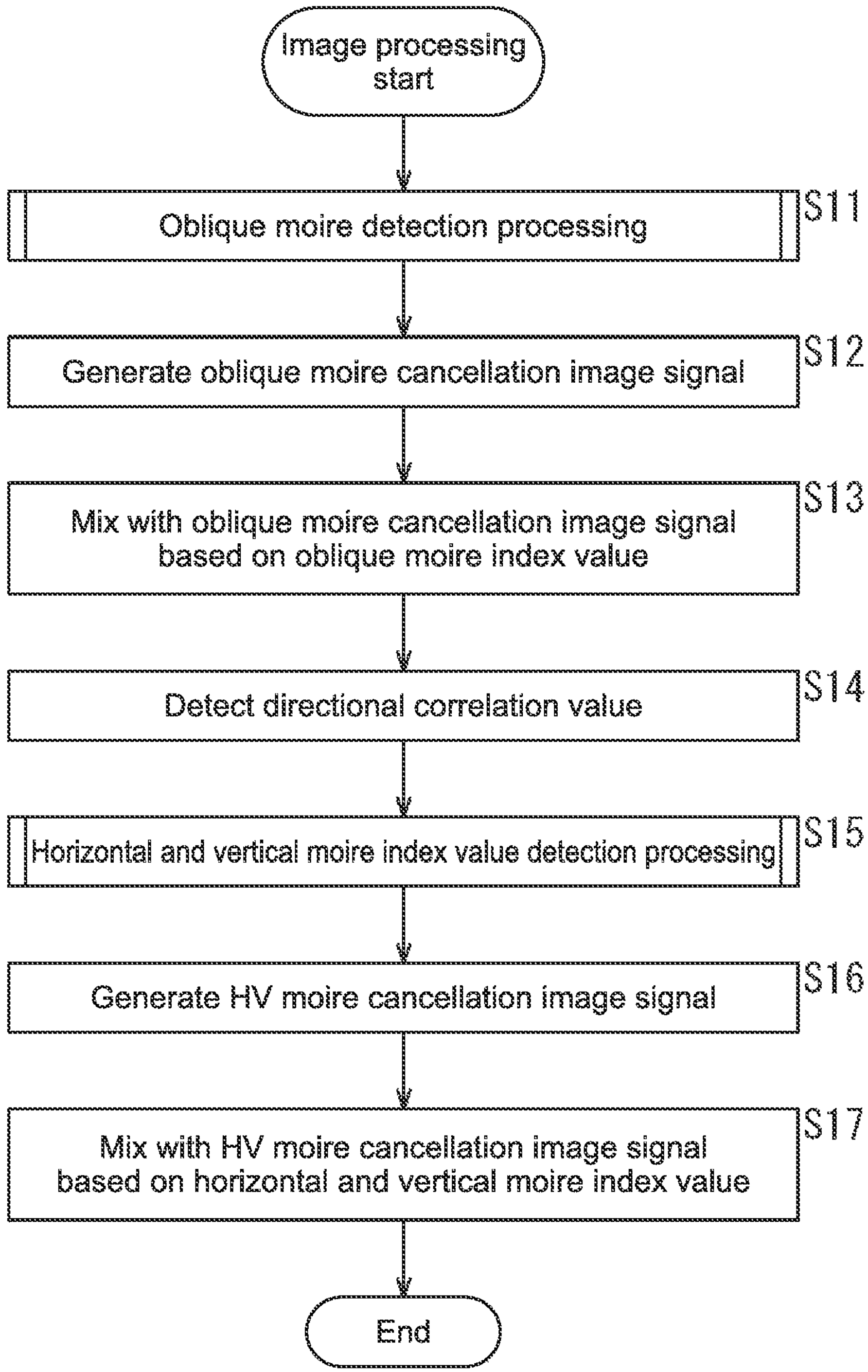
Image processing start
Oblique moire detection processing
S11
Generate oblique moire cancellation image signal
S12
Mix with oblique moire cancellation image signal based on oblique moire index value
S13
Detect directional correlation value
S14
Horizontal and vertical moire index value detection processing
S15
Generate HV moire cancellation image signal
S16
Mix with HV moire cancellation image signal based on horizontal and vertical moire index value
S17
End

FIG.6

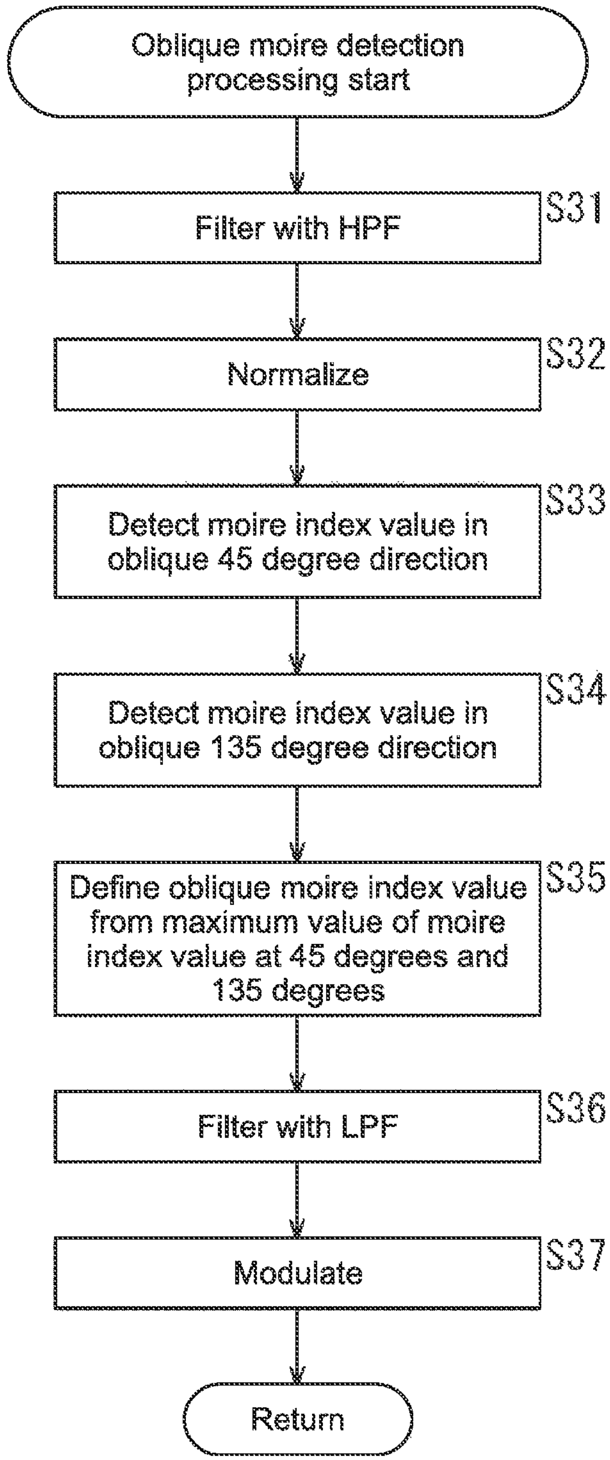
Oblique moire detection processing start
Filter with HPF
S31
Normalize
S32
Detect moire index value in oblique 45 degree direction
S33
Detect moire index value in oblique 135 degree direction
S34
Define oblique moire index value from maximum value of moire index value at 45 degrees and 135 degrees
S35
Filter with LPF
S36
Modulate
S37
Return

FIG.7

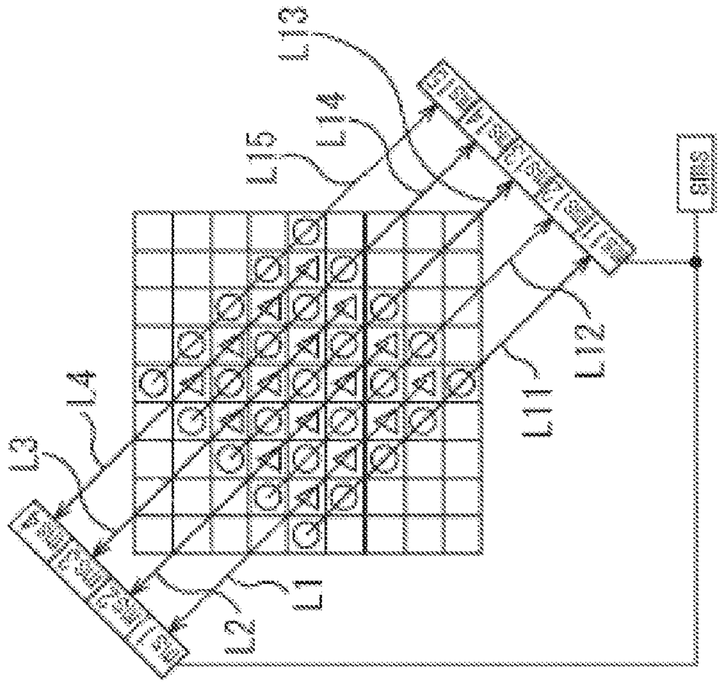
L13
L14
L15
L4
L3
L12
L11
L1
L2
sms

FIG. 8B

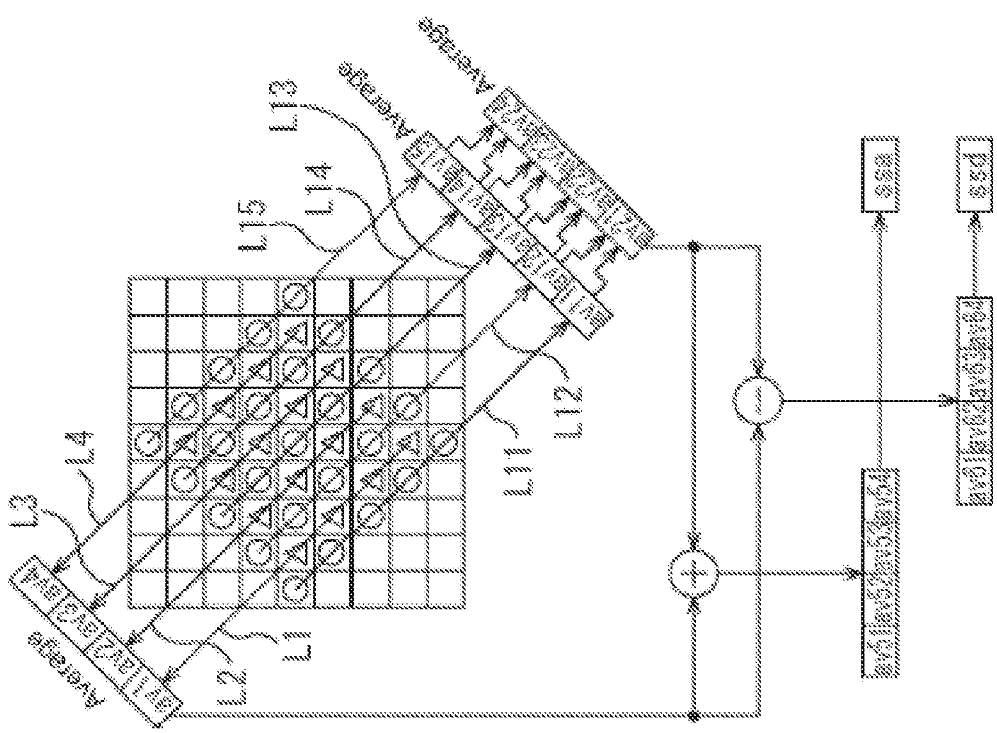
Average
Average
Average
L13
L14
L15
L4
L3
L12
L11
L1
L2
ssa
ssd

FIG. 8A

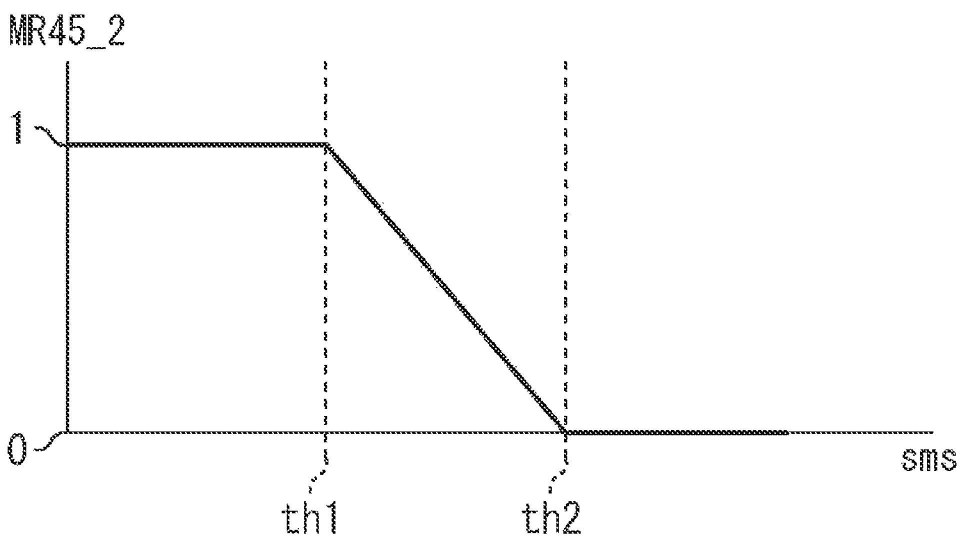

FIG.9

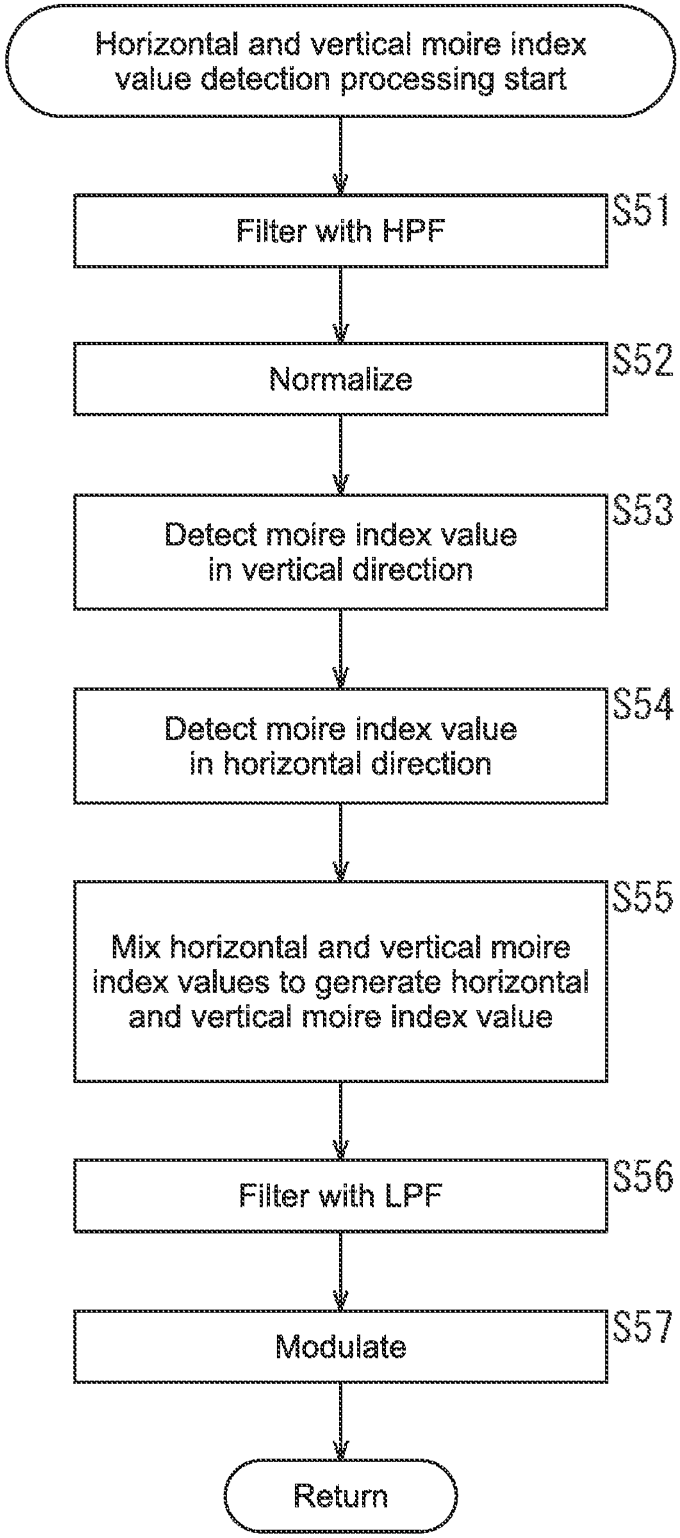
Horizontal and vertical moire index value detection processing start
Filter with HPF
S51
Normalize
S52
Detect moire index value in vertical direction
S53
Detect moire index value in horizontal direction
S54
Mix horizontal and vertical moire index values to generate horizontal and vertical moire index value
S55
Filter with LPF
S56
Modulate
S57
Return

FIG.10

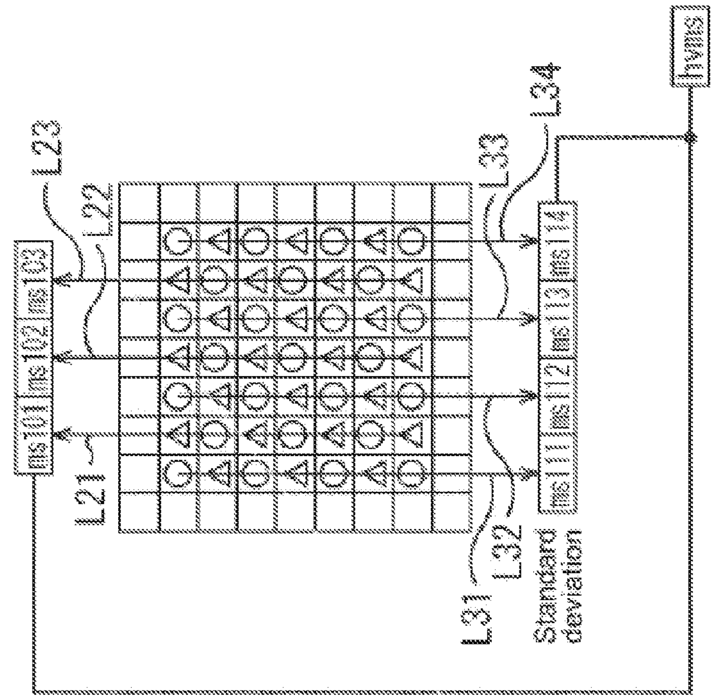

FIG. 11B

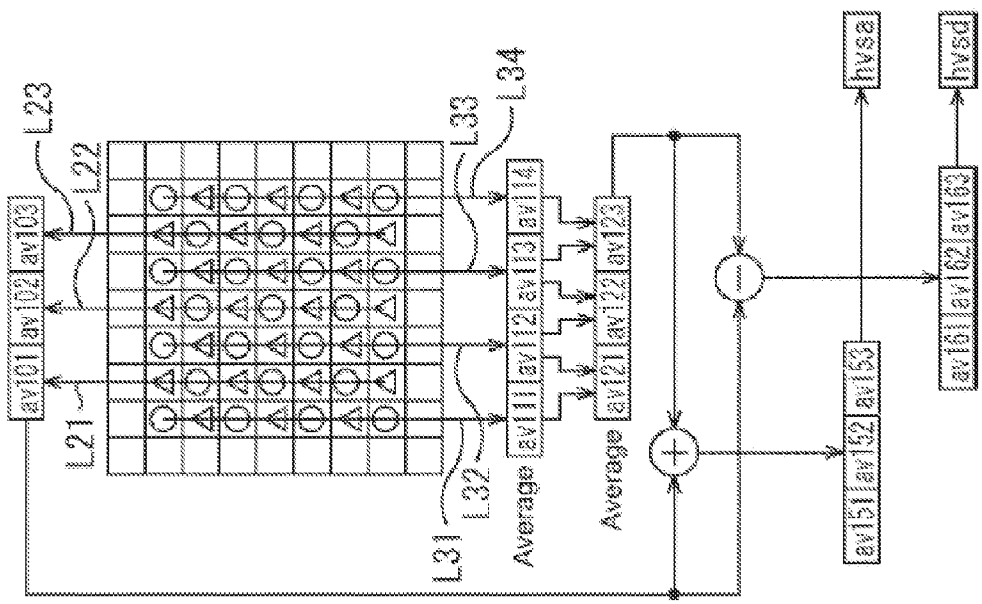

FIG. 11A

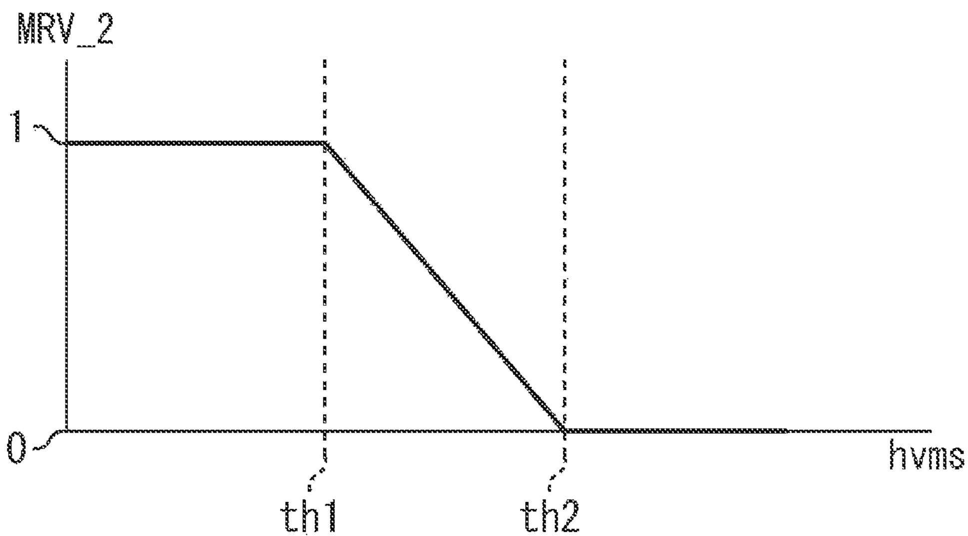

FIG.12

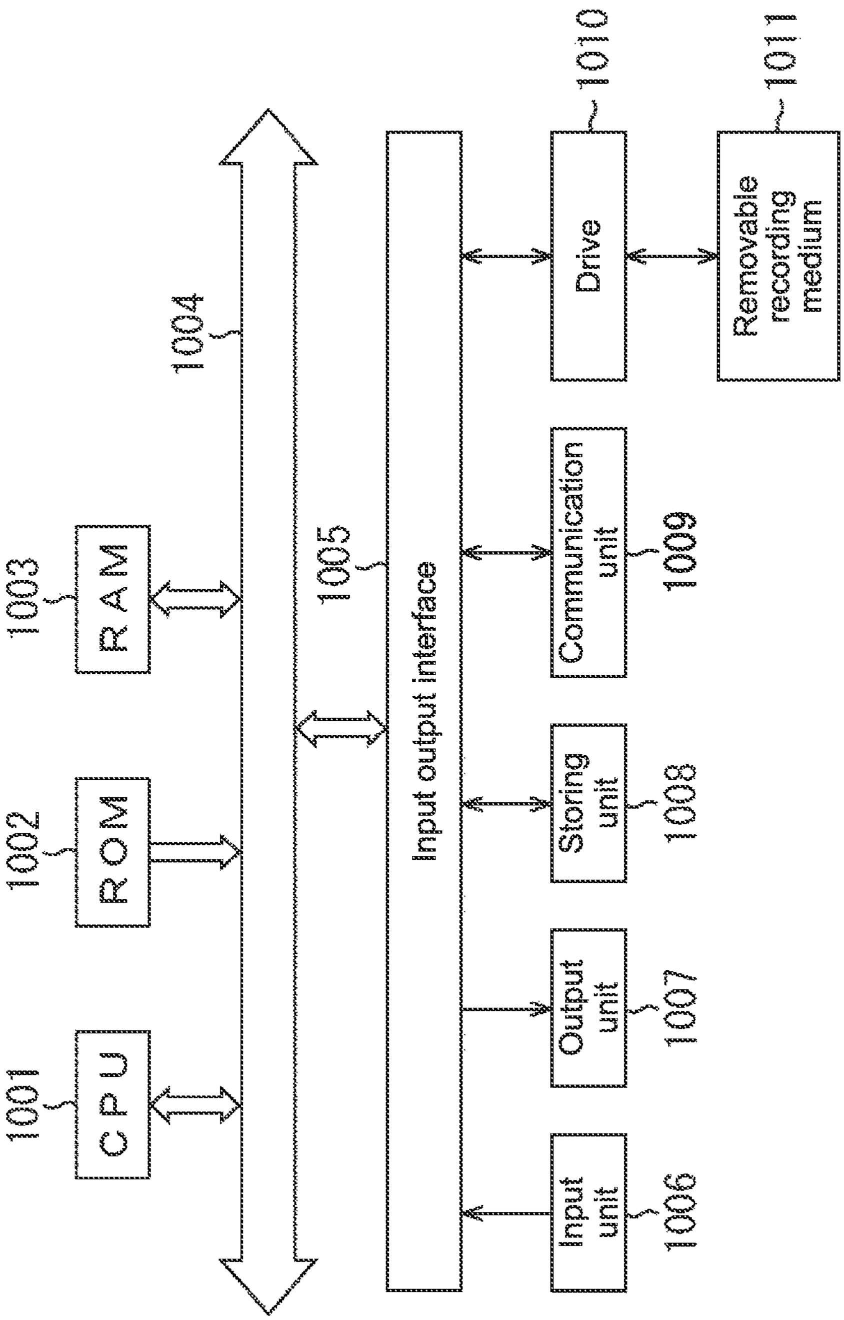
1001
CPU
1002
ROM
1003
RAM
1004
1005
Input output interface
Input unit
1006
Output unit
1007
Storing unit
1008
Communication unit
1009
Drive
1010
Removable recording medium
1011

FIG.13

IMAGE PROCESSING APPARATUS, METHOD THEREOF AND PROGRAM THEREFOR

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Japanese Priority Patent Application JP 2014-034972 filed Feb. 26, 2014, the entire contents of which are incorporated herein by reference.

BACKGROUND

The present technology relates to an image processing apparatus, a method thereof and a program therefor. More particularly, the present technology relates to an image processing apparatus, a method thereof and a program therefor that can prevent a false color from generating caused by color moire.

An image capturing apparatus has a color filer having spectroscopic properties in each pixel, photoelectrically converts light having a wavelength being different in each pixel, and samples a digital signal.

A general image capturing apparatus having the Bayer array is composed of RGB (Red, Green, Blue) color filters. A half of pixels has green filters, and the rest half of the pixels has red and blue color filters.

The color filters may generate a false color. A countermeasure technology thereof has been suggested (see Japanese Patent Application Laid-open No. 2013-048410 (US2012/0293696), Japanese Patent Application Laid-open No. 2012-104968 (US2013/0222531), Japanese Patent Application Laid-open No. 2009-253616 and Japanese Patent Application Laid-open No. 2006-121453 (US2006/0087569)).

SUMMARY

In general, the image capturing apparatus performs synchronization processing on three colors RGB (Red, Green, Blue) in each pixel. The synchronization processing may cause turnback due to a difference in sampling frequencies of the respective colors.

The turnback may be seen a periodic false color (color moire).

However, the above-described technologies according to Japanese Patent Application Laid-open No. 2013-048410, Japanese Patent Application Laid-open No. 2012-104968, Japanese Patent Application Laid-open No. 2009-253616 and Japanese Patent Application Laid-open No. 2006-121453 may not prevent the false color caused by the color moire.

In view of the circumstances as described above, there is a need to prevent a decrease in a resolution, to inhibit color bleeding as well as a generation of a false color caused by the color moire.

According to an embodiment of the present technology, there is provided an image processing apparatus, including: a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array; a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and a moire suppression

unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit.

The direction detection unit may detect a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction. The moire detection unit may includes a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction; a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and may output the moire index value generated by the mixed processing unit as a detection result.

The image processing apparatus may further includes a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image. The moire suppression unit may suppresses moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value.

The horizontal and vertical moire reduced image generation unit may be a filter having a low pass property in a horizontal direction and a vertical direction to each pixel of the input image.

The image processing apparatus may further includes an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value. The moire suppression unit may suppress the moire level in the input image by mixing the input image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

The oblique moire detection unit may include an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction; an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and may output the oblique moire index value detected by the maximum value detection unit as a detection result.

The oblique moire reduced image generation unit may be a filter having a low pass property in the oblique direction to each pixel of the input image.

The image processing apparatus may further includes a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image, an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value. The direction detection unit may detect a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction.

the moire detection unit may include a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction; a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and

a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and may output the moire index value generated by the mixed processing unit as a detection result. The oblique moire detection unit may include an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction; an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and may output the oblique moire index value detected by the maximum value detection unit as a detection result.

The moire suppression unit may suppress the moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value to generate a primary moire suppression image, and by mixing the primary moire suppression image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value. The color pixel array may be a Bayer array.

According to an embodiment of the present technology, there is provided a method of processing an image, including: detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array; detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and suppressing the moire level in the input image based on the moire index value detected.

According to an embodiment of the present technology, there is provided a program for causing a computer to execute a method of: detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array; detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and suppressing the moire level in the input image based on the moire index value detected.

These and other objects, features and advantages of the present technology will become more apparent in light of the following detailed description of best mode embodiments thereof, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram showing an illustrative configuration of an image processing apparatus according to an embodiment of the present technology;

FIG. **2** is a block diagram for showing an image processing unit having the illustrative configuration according to an embodiment of the present technology in FIG. **1**;

FIG. **3** is a diagram of illustrative configurations of an LPF to suppress a moire level;

FIG. **4** is a diagram of an HPF for detecting an index value showing a moire level and an LPF for filtering a detection result of the index value showing the moire level;

FIG. **5** is a diagram of illustrative configurations of filters for detecting a directional correlation value;

FIG. **6** is a flow chart of image processing by the image processing unit in FIG. **2**;

FIG. **7** is a flow chart of oblique moire index value detection processing;

FIGS. **8**A and **8**B each illustrates the oblique moire index value detection processing;

FIG. **9** is a graph illustrating the oblique moire index value detection processing;

FIG. **10** is a flow chart of horizontal and vertical moire index value detection processing;

FIGS. **11**A and **11**B each illustrates the horizontal and vertical moire index value detection processing;

FIG. **12** is a graph illustrating the horizontal and vertical moire index value detection processing; and

FIG. **13** is a diagram of an illustrative configuration of a general purpose personal computer.

DETAILED DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the present technology will be described with reference to the drawings.

<Illustrative Configuration of Image Processing Apparatus>

FIG. **1** shows an illustrative configuration of an image processing apparatus according to an embodiment of the present technology. The image processing apparatus shown in FIG. **1** outputs an image signal by suppressing a color moire level depending on the color moire level of an input image.

Specifically, the image processing apparatus shown in FIG. **1** includes an optical image capturing unit **1**, an image capturing element **2**, an image processing unit **3**, an image recording unit **4** and an image display unit **5**.

The optical image capturing unit **1** is composed of an optical device such as a lens, and focuses an incident light on the image capturing element **2**.

The image capturing element **2** is composed of a CCD (Charge Coupled Device), a CMOS (Complementary Metal Oxide Semiconductor) or the like, generates charges by a photoelectric effect caused by the incident light focused by the image capturing unit **1**, generates an image signal based on the charges generated and outputs the image signal to the image processing unit **3**.

The image processing unit **3** inhibit a false color caused by the color moire induced on the image signal supplied from the image capturing element **2**, and outputs and records the image signal to/on the image recording unit **4** such as an HDD (Hard Disc Drive) and an SSD (Solid State Drive) or outputs and displays the image signal on the image display unit **5** such as an LCD (Liquid Crystal Display) and an organic EL (Electro Luminescence).

<Illustrative Embodiment of Image Processing Unit>

Next, referring to the block diagram shown in FIG. **2**, an illustrative embodiment of the image processing unit **3** will be described.

The image processing unit **3** includes a moire cancellation unit **11**, a moire suppression unit **12**, an oblique moire index value detection unit **13** and a horizontal and vertical moire index value detection unit **14**.

The moire cancellation unit **11** reduces and outputs moire induced in horizontal, vertical and oblique directions from the input image. Specifically, the moire cancellation unit **11** includes an oblique LPF (Low Pass Filter) **31** and an HV (Horizontal direction and Vertical direction) LPF **32**.

The oblique LPF **31** is a filter for reducing and cancelling the moire in the oblique direction from the input image signal as shown at a right side of FIG. **3**, for example. The oblique LPF **31** reduces the moire in the oblique direction from the input image signal and outputs an oblique moire cancellation image signal from the image signal to a mixed processing unit **41** in the moire suppression unit **12**. The filter at the right side of FIG. **3** is a 9-pixel filter of 3 pixels×3 pixels where a pixel of interest at a center position is surrounded by 8 pixels. Filter coefficients are: 1, 0, 1 from left to right at an upper row, 0, 4, 0 from left to right at a middle row, and 1, 0, 1 from left to right at a lower row.

The filter shown at the right side of FIG. **3** is only illustrative of the LPF **31**. Any filter that reduces and cancels the moire in the oblique direction from the input image signal may be used. The filter at the right side of FIG. **3** includes 3 pixels×3 pixels. Any filter having different sizes having the similar functions may be used. Also, filters described later are only illustrative. As long as they have the similar functions, other filter coefficients and sizes may be used.

The HV (horizontal direction and vertical direction) LPF **32** is a filter for reducing and cancelling the moire in the horizontal direction and the vertical direction from the input image signal as shown at a left side of FIG. **3**, for example. The HV LPF **32** reduces the moire in the horizontal direction and the vertical direction from the input image signal and outputs the HV moire cancelled from the image signal to a mixed processing unit **42** in the moire suppression unit **12**. The filter at the left side of FIG. **3** is a 9-pixel filter of 3 pixels×3 pixels where a pixel of interest at a center position is surrounded by 8 pixels. Filter coefficients are: 0, 1, 0 from left to right at an upper row, 1, 4, 1 from left to right at a middle row, and 0, 1, 0 from left to right at a lower row.

The moire suppression unit **12** includes the mixed processing units **41**, **42**. Based on an oblique moire index value supplied from the oblique moire index value detection unit **13** and a horizontal and vertical moire index value supplied from the horizontal and vertical moire index value detection unit **14**, the input image is mixed with an oblique moire cancellation image signal and an HV moire cancellation image signal to suppress the moire.

Specifically, the mixed processing unit **41** mixes the input image signal and the oblique moire cancellation image signal in a pixel unit at a mixing ratio based on the oblique moire index value supplied from the oblique moire index value detection unit **13** and outputs an oblique moire cancellation mixed image signal to the mixed processing unit **42**.

The mixed processing unit **42** mixes the oblique moire cancellation mixed image signal and the HV moire cancellation image signal in a pixel unit at a mixing ratio based on the HV moire index value supplied from the horizontal and vertical moire index value detection unit **14** and generates and outputs an output image signal.

The oblique moire index value detection unit **13** detects the oblique moire index value showing a moire level in the oblique direction from the input image signal, especially, in a 45 degree direction and a 135 degree direction, and outputs the value to the mixed processing units **41** in the moire suppression unit **12**.

Specifically, the oblique moire index value detection unit **13** includes a normalization unit **51**, an oblique moire detection unit **52**, an LPF **53** and a modulation unit **54**.

The normalization unit **51** includes an HPF (High Pass Filter) of 3 pixels×3 pixels where a pixel of interest at a center position is surrounded by 8 pixels as shown at a left side of FIG. **4**, for example, and a normalization processing unit. Firstly, the normalization unit **51** performs a high pass filter (HPF) processing on each pixel of the input image signal in order to improve an accuracy of a detection processing in a later step. Further, the normalization unit **51** determines a standard deviation within a range of 3 pixels×3 pixels where the pixel of interest at a center position is filtered by the HPF, normalizes the input image signal by the standard deviation, and outputs the input image signal to an MR45 detection unit **71** and an MR 135 detection unit **72**.

Here, the HPF at a left side of FIG. **4** is a 9-pixel filter of 3 pixels×3 pixels where a pixel of interest at a center position is surrounded by 8 pixels. Filter coefficients are: 1, −2, 1 from left to right at an upper row, −2, 4, −2 from left to right at a middle row, and 1, −2, 1 from left to right at a lower row.

The oblique moire detection unit **52** includes the MR45 detection unit **71**, the MR 135 detection unit **72** and a maximum value detection unit **73**, and detects a moire index value MR showing the moire level in the oblique direction from the input image signal.

Specifically, the MR45 detection unit **71** calculates the moire in an oblique 45 degree direction to the horizontal direction, i.e., an oblique 45 degree moire index value MR45 showing an oblique moire level based on the input image signal normalized, and output the oblique 45 degree moire index value MR45 to the maximum value detection unit **73**.

The MR 135 detection unit **72** calculates the moire in an oblique 135 degree direction to the horizontal direction, i.e., an oblique 135 degree moire index value MR135 showing an oblique moire level based on the input image signal normalized, and output the oblique 135 degree moire index value MR135 to the maximum value detection unit **73**.

The maximum value detection unit **73** outputs any of the maximum value of the oblique 45 degree moire index value MR45 showing an oblique moire level and the oblique 135 degree moire index value MR135.

The LPF **53** is the filter at the right side of FIG. **4** of 3 pixels×3 pixels and smooths the moire index value MR showing a possibility of moire in the oblique direction, and outputs the moire index value MR to the modulation unit **54**. The LPF **53** at the right side of FIG. **4** is a 9-pixel filter of 3 pixels×3 pixels where a pixel of interest at a center position is surrounded by 8 pixels. Filter coefficients are: 1, 1, 1 from left to right at an upper row, 1, 1, 1 from left to right at a middle row, and 1, 1, 1 from left to right at a lower row.

The modulation unit **54** modulates an oblique moire index value MR to decrease a high detection value thereof and output the oblique moire index value MR to the mixed processing unit **41**.

The vertical moire index value detection unit **14** detects an HV moire index value MRHV showing the moire level in the horizontal and vertical directions from the input image signal, and outputs the HV moire index value MRHV to the mixed processing unit **42** in the moire suppression unit **12**.

Specifically, the vertical moire index value detection unit **14** includes a normalization unit **61**, a horizontal and vertical moire detection unit **62**, an LPF **63**, a modulation unit **64** and an HV correlation detection unit **65**.

The normalization unit **61** has a basic structure having the same functions as the normalization unit **51**.

The horizontal and vertical moire detection unit **62** includes an MRH detection unit **81**, an MRV detection unit **82** and a mixed processing unit **83**, and detects the HV moire index value MRHV showing the moire level in the horizontal and vertical directions from the input image signal.

Specifically, the MRH detection unit **81** calculates the moire in the horizontal direction, i.e., an H (horizontal) moire index value MRH showing the H (horizontal) moire level based on the input image signal normalized, and output the H (horizontal) moire index value MRH to the mixed processing unit **83**.

The MRV detection unit **82** calculates the moire in the vertical direction, i.e., a V (vertical) moire index value MRV showing the V (vertical) moire level based on the input image signal normalized, and output the V (vertical) moire index value MRV to the mixed processing unit **83**.

The mixed processing unit **83** mixes the H (horizontal) moire index value MRH and the V (vertical) moire index value MRV based on a directional correlation value supplied from the HV correlation detection unit **65** to generate the HV moire index value MRHV and outputs the HV moire index value MRHV to the LPF **63**.

The HV correlation detection unit **65** detects the directional correlation value showing that, for each pixel of the picture pattern, using a pixel value of 5 pixels×5 pixels at which a pixel of interest is centered, the surrounding pixels belong to the image in the vertical direction or the surrounding pixels belong to the image in the vertical direction. Specifically, the HV correlation detection unit **65** detects a directionality per color filter, i.e., by a sum of a processing result by a band pass filter (BPF) of surrounding green pixels.

As an illustrative detection of a horizontal directionality (dh), when an each pixel array is the Bayer array and each center pixel is a green pixel, a sum of a (−1, 2, −1) filter processing result at three positions in the horizontal direction as shown in a leftmost column in FIG. **5**. When each center pixel is a red or blue pixel, the HV correlation detection unit **65** detects the directionality by a sum of a (−1, 2, −1) filter processing result at two positions in the horizontal direction as shown in the second column from the right in FIG. **5**.

On the other hand, as to a vertical directionality (dv), the HV correlation detection unit **65** performs filter processing at 90 degree rotation on the filters in the second column from the left column and the rightmost column as shown in the leftmost column and the second column from the right column in FIG. **5**.

Then, the HV correlation detection unit **65** calculates the directional correlation value (dhv) as a ratio dhv (=dh/(dh+dv)) of the directionalities in the vertical and horizontal directions, and outputs the directional correlation value (dhv) to the mixed processing unit **83**.

Although the Bayer array is described referring to FIG. **5**, any other array may be used as long as it match an RGB color array.

The mixed processing unit **83** mixes the H moire index value MRH showing the moire level in the horizontal direction and the V moire index value MRV showing the moire level in the vertical direction based on the ratio dhv and outputs the HV moire index value MRHV (=dh/(dh+dv)×MRH+((1−dh/(dh+dv))×MRV) to the LPF **63**.

The LPF **63** has the similar functions as the LPF **53**, is the filter at the right side of FIG. **4** of 3 pixels×3 pixels and smooths the HV moire index value MRHV showing a possibility of moire in the horizontal and vertical directions, and outputs the HV moire index value MRHV to the modulation unit **64**.

The modulation unit **64** modulates the HV moire detection value MRHV to decrease a high detection value thereof and output the HV moire detection value MRHV to the mixed processing unit **42** in the moire suppression unit **12**.

<Image processing by Image Processing Unit in FIG. **2**>

Next, referring to a flow chart in FIG. **6**, image processing by the image processing unit in FIG. **2** will be described.

In Step S**11**, the oblique moire index value detection unit **13** preforms oblique moire detection processing to detect the oblique moire index value MR.

<Oblique Moire Index Value Detection Processing>

Here, referring to a flow chart in FIG. **7**, the oblique moire detection processing by the oblique moire index value detection unit **13** will be described.

In Step S**31**, the normalization unit **51** filters each pixels of the input image signal using the HPF of 3 pixels×3 pixels shown at the left side of FIG. **4** to perform high pass filter processing.

In Step S**32**, the normalization unit **51** determines a standard deviation within a range of 3 pixels×3 pixels where each pixel of the input image signal is subjected to the high pass filter processing, normalizes the input image signal by the standard deviation, and outputs the input image signal to the oblique moire detection unit **52**.

In Step S**33**, the MR45 detection unit **71** of the oblique moire detection unit **52** detects the moire in an oblique 45 degree direction to the horizontal direction, i.e., an oblique 45 degree moire index value MR45 showing an oblique moire level for each pixel of the input image signal normalized, and outputs the oblique 45 degree moire index value MR45 to the maximum value detection unit **73**.

Specifically, the MR45 detection unit **71** calculates average values av**1** to av**4** of the pixel value about respective pixel columns L**1** to L**4** including four pixels shown as triangles in FIG. **8**A among the respective pixels of the input image signal normalized within a range of 9 pixels×9 pixels where the pixel of interest is placed at a center position. Also, the MR45 detection unit **71** calculates average values av**11** to av**15** of the pixel value about respective pixel columns L**1** to L**4** including five pixels shown as circles in FIG. **8**A.

The MR45 detection unit **71** calculates an average value av**21** of the average values av**11** and av**12**, an average value av**22** of the average values av**12** and av**13**, an average value av**23** of the av**13** and av**14** and an average value av**24** of the average values av**14** and av**15**, as shown in FIG. **8**A. By this processing, phases of the average values av**21** to av**24** provided from the triangle pixels and of the average values av**1** to av**4** provided from the circle pixels are aligned.

The MR45 detection unit **71** calculates an average value sum av**51** of a sum of the average values av**1** and av**12**, an average value sum av**52** of a sum of the average values av**2** and av**22**, an average value sum av**53** of a sum of the av**3** and av**23** and an average value sum av**54** of a sum of the average values av**4** and av**24**, as shown in FIG. **8**A.

The MR45 detection unit **71** calculates an average value difference av**61** of a difference of the average values av**1** and av**21**, an average value difference av**62** of a difference of the average values av**2** and av**22**, an average value difference av**63** of a difference of the av**3** and av**23** and an average value difference av**64** of a difference of the average values av**4** and av**24**, as shown in FIG. **8**A.

The MR45 detection unit **71** calculates a sum standard deviation ssa of the sum of the average values av**51** to av**54** and a difference standard deviation ssd of the difference of the average values av**61** to av**64**.

The MR45 detection unit **71** calculates standard deviations ms**1** to ms**4** and ms**11** to ms**15** of the respective pixel values in pixel columns L**1** to L**4** and L**11** and L**14**, and calculates the average value thereof as a standard deviation average value sms, as shown in FIG. **8**B.

The MR45 detection unit **71** calculates an MR45 first index MR45_1 defined by the following equation (1):

$$MR45\_1=\max(0,ssd-ssa)/(ssd+ssa+eps)) \quad (1)$$

Here, the MR45_1 represents the MR45 first index, max (A, B) represents a function that selects a maximum value of A or B, ssd represents the difference standard deviation, ssa represents the sum standard deviation, and eps represents a predetermined constant to avoid that the denominator becomes 0 in the calculation by the equation (1).

The MR45 detection unit **71** specifies an MR45 second index MR45_2 with the function specified by the standard deviation average value sms as shown in FIG. **9**. In FIG. **9**, a vertical axis represents the MR45 second index MR45_2 and a horizontal axis represents the standard deviation average value sms. In other words, when the standard deviation average value sms is zero to a threshold value th**1**, the MR45 second index MR45_2 will be 1. When the standard deviation average value sms is threshold values th**1** to th**2**, the MR45 second index MR45_2 will be an inverse value to the standard deviation average value sms. When the standard deviation average value sms exceeds the threshold value th**2**, the MR45 second index MR45_2 will be zero.

Then, the MR45 detection unit **71** calculates the oblique 45 degree moire index value MR45 showing the oblique moire level in the oblique 45 degree direction by the calculation represented by the following equation:

$$MR45=MR45\_1\times MR45\_2 \quad (2)$$

Here, MR45 represents the oblique 45 degree moire index value showing the oblique moire level in the oblique 45 degree direction, the MR45_1 represents the MR45 first index, and the MR45_2 represents the MR45 second index.

The MR45 detection unit **71** calculates the difference standard deviation ssd and the sum standard deviation ssa, whereby an index value showing whether or not there is periodicity in the pixel columns L**1** to L**4** and L**11** to L**15** formed surrounding the respective pixels. For example, as shown in FIG. **8**A, when periodicity having same phases or opposite phases is generated between the pixel columns L**1** to L**4** represented by the triangles and the pixel columns L**11** to L**15** represented by the circles, either the difference standard deviation ssd or the sum standard deviation ssa will have a greater value. If the color moire is induced, the MR45 first index MR45_1 will have a great value.

On the other hand, although the MR45 first index MR45_1 has a great value, the standard deviation average value sms shown in FIG. **8**B. has a great value when no moire is induced and the image has an actual color combination varied widely. In this case, due to the properties of the MR45 second index MR45_2 shown in FIG. **9**, the MR45 second index MR45_2 has a small value. In contrast, if the standard deviation average value sms is small and is less varied, the MR45 second index MR45_2 will become 1. So, the MR45 first index MR45_1 will be the 45 degree moire index value MR45.

As a result, this processing can provide the oblique 45 degree moire index value MR45 showing the oblique moire level in the oblique 45 degree direction.

In Step S**34**, the MR 135 detection unit **72** calculates the moire in an oblique 135 degree direction to the horizontal direction, i.e., an oblique 135 degree moire index value MR135 showing an oblique moire level about the respective pixels of the input image signal normalized, and output the oblique 135 degree moire index value MR135 to the maximum value detection unit **73**. The processing in the MR 135 detection unit **72** is similar to that in the MR45 detection unit **71** except that the pixel columns to be processed is rotated 90 degrees, and therefore a description thereof will be omitted.

In Step S**35**, the maximum value detection unit **73** feeds the maximum value in the respective pixels of the oblique 45 degree moire index value MR45 fed from the MR45 detection unit **71** and the oblique 135 degree moire index value MR135 fed from the MR135 detection unit **72** to an LPF **53** as the moire index value MR.

In Step S**36**, the LPF **53** performs a low pass filter processing on the moire index value MR45 fed from the maximum value detection unit **73** in each pixel using the filter shown in the right side of FIG. **4**, and outputs the moire index value MR45 to the modulation unit **54**.

In Step S**37**, the modulation unit **54** performs a modulation processing on the oblique moire index value MR to which the low pass filter processing is performed in each pixel to decrease a high detection value and outputs the oblique moire index value MR to the mixed processing unit **41** in the moire suppression unit **12**.

In other words, the oblique moire index value MR showing the moire level in the oblique direction in each pixel is determined by the oblique moire detection processing described by referring to the flow chart in FIG. **7**, and is fed to the mixed processing unit **41** in the moire suppression unit **12**. As the oblique moire index value MR determined here has a value of 0 or 1, which can be used as it is as the mixing ratio with the oblique moire cancellation image signal.

Here, it returns to the description of the flow chart in FIG. **6**.

In Step S**12**, the oblique LPF **31** is the filter for cancelling the moire in the oblique direction from each pixel of the input image signal as shown at a right side of FIG. **3**, for example, and generates and outputs the oblique moire cancellation image signal to the mixed processing unit **41**.

In Step S**13**, the mixed processing unit **41** mixes each pixel of the input image signal and each pixel of the oblique moire cancellation image signal at a mixing ratio based on the oblique moire index value MR supplied from the modulation unit **54** and generates and outputs a primary moire suppression image signal to the mixed processing unit **42**.

In Step S**14**, the HV correlation detection unit **65** in the vertical moire index value detection unit **14** detects the directional correlation value of each pixel based on the input image signal to the mixed processing unit **83**.

Specifically, the HV correlation detection unit **65** detects a directionality per color filter by a sum of a processing result by a band pass filter (BPF) of surrounding green pixels. As an illustrative detection of a horizontal directionality (dh), when the pixel of interest is a green pixel, the HV correlation detection unit **65** detects the directionality by a sum of a (−1, 2, −1) filter processing result at three positions in the horizontal direction as shown in a leftmost column in FIG. **5**. When the pixel or interest is a red or blue pixel, the HV correlation detection unit **65** detects the directionality by a sum of a (−1, 2, −1) filter processing result at two positions in the horizontal direction as shown in the second column from the right in FIG. **5**.

As to a vertical directionality (dv), when the pixel of interest is a green pixel, the HV correlation detection unit **65** determines the directionality by a sum of a (−1, 2, −1) filter processing result at three positions in the horizontal direction as shown in the second column from the left in FIG. **5**. When the pixel or interest is a red or blue pixel, the HV correlation detection unit **65** detects the directionality by a sum of a (−1, 2, −1) filter processing result at two positions in the horizontal direction as shown in the rightmost column in FIG. **5**.

In other words, as to a vertical directionality (dv), filter processing at 90 degree rotation is performed on the filters in the second column from the left and the rightmost columns as shown in the leftmost column and the second column from the right column in FIG. **5**.

Then, the HV correlation detection unit **65** calculates the directional correlation value (dhv) as a ratio dhv (=dh/(dh+dv)) of the directionalities in the vertical and horizontal directions, and outputs the directional correlation value (dhv) to the mixed processing unit **83**.

In Step S**15**, the vertical moire index value detection unit **14** performs horizontal and vertical moire index value detection processing to detect the HV moire index value MRHV.

<Horizontal and Vertical Moire Index Value Detection Processing>

Here, referring to a flow chart in FIG. **10**, the horizontal and vertical moire index value detection processing in the vertical moire index value detection unit **14** will be described.

In Step S**51**, the normalization unit **61** filters each pixels of the input image signal using the HPF of 3 pixels×3 pixels shown at the left side of FIG. **4** to perform high pass filter processing.

In Step S**52**, the normalization unit **61** determines a standard deviation within a range of 3 pixels×3 pixels where each pixel of the input image signal is subjected to the high pass filter processing, normalizes the input image signal by the standard deviation, and outputs the input image signal to the oblique moire detection unit **62**.

In Step S**53**, the MRV detection unit **82** of the horizontal and vertical moire detection unit **62** calculates the moire in the vertical direction, i.e., a vertical moire index value MRV showing a vertical moire level for each pixel of the input image signal normalized, and output the vertical moire index value MRV to the mixed processing unit **83**.

Specifically, the MRV detection unit **82** calculates average values av**101** to av**103** of the pixel value about respective pixel columns L**21** to L**23** including seven pixels shown as circles or triangles in FIG. **11**A among the respective pixels in the vertical direction of the input image signal normalized within a range of 7 pixels×7 pixels where the pixel of interest is placed at a center position. Also, the MRV detection unit **82** calculates average values av**111** to av**114** of the pixel value about respective pixel columns L**31** to L**34** including seven pixels shown as circles or triangles in FIG. **11**A.

The MRV detection unit **82** calculates an average value av**121** of the average values av**111** and av**112**, an average value av**122** of the average values av**112** and av**113** and an average value av**123** of the av**113** and av**114**, as shown in FIG. **11**A.

Furthermore, the MRV detection unit **82** calculates an average value sum av**151** of a sum of the average values av**101** and av**102**, an average value sum av**152** of a sum of the average values av**102** and av**122** and an average value sum av**153** of a sum of the av**103** and av**123**, as shown in FIG. **11**A.

The MRV detection unit **82** calculates an average value difference av**161** of a difference of the average values av**101** and av**121**, an average value difference av**162** of a difference of the average values av**102** and av**122** and an average value difference av**163** of a difference of the av**103** and av**123**, as shown in FIG. **11**A.

The MRV detection unit **82** calculates a sum standard deviation hvsa of the sum of the average values av**151** to av**154** and a difference standard deviation hvsd of the difference of the average values av**161** to av**163**.

The MRV detection unit **82** calculates standard deviations ms**101** to ms**103** and ms**111** to ms**114** of the respective pixel values in pixel columns L**21** to L**23** and L**31** and L**34**, and calculates the average value thereof as a standard deviation average value hums, as shown in FIG. **11**B.

The MRV detection unit **82** calculates an MRV first index MRV **1** defined by the following equation (3):

$$MRV\_1=\max(0,(hvsd-hvsa)/(hvsd+hvsa+eps)) \quad (3)$$

Here, the MRV_1 represents the MRV first index, max (A, B) represents a function that selects a maximum value of A or B, hvsd represents the difference of the standard deviations, hvsa represents the sum of the standard deviations, and eps represents a predetermined constant to avoid that the denominator becomes 0 in the calculation by the equation (3).

The MRV detection unit **82** specifies an MRV second index MRR_2 with the function specified by the standard deviation average value hvms as shown in FIG. **12**. In FIG. **12**, a vertical axis represents the MRV second index MRV_2 and a horizontal axis represents the standard deviation average value hvms. In other words, when the standard deviation average value hvms is zero to a threshold value th**1**, the MRV second index MRV_2 will be 1. When the standard deviation average value hvms is threshold values th**1** to th**2**, the MRV second index MRV_2 will be an inverse value to the standard deviation average value hvms. When the standard deviation average value hvms exceeds the threshold value th**2**, the MRV second index MRV_2 will be zero.

Then, the MRV detection unit **82** calculates the oblique 45 degree moire index value MRV showing the oblique moire level in the oblique 45 degree direction by the calculation represented by the following equation:

$$MRV=MRV\_1\times MRV\_2 \quad (4)$$

Here, MRV represents the vertical moire index value showing the vertical moire level in the vertical direction, the MRV_1 represents the MRV first index, and the MRV_2 represents the MRR second index.

The MRV detection unit **82** calculates the difference of the standard deviations hvsd and the sum of the standard deviations hvsa, whereby an index value showing whether or not there is periodicity in the pixel columns L**21** to L**23** and L**31** to L**34** formed surrounding the respective pixels. For example, as shown in FIG. **11**A, when periodicity having same phases or opposite phases is generated between the pixel columns L**21** to L**23** including seven pixels represented by the circles or triangles and the pixel columns L**31** to L**34** including seven pixels represented by the circles or triangles, either the difference of the standard deviations hvsd or the sum of the standard deviations hvsa will have a greater value. If the color moire is induced, the MRV first index MRV_1 will have a great value.

On the other hand, even if the MRV first index MR45_1 has a great value, if no moire is induced and the image has an actual color combination varied widely, the standard deviation average value hums shown in FIG. **12**B has a great value. In this case, due to the properties of the MRV second index MR45_2 shown in FIG. **12**, the MRV second index MR45_2 has a small value. In contrast, if the standard deviation average value hums is small and is less varied, the

MRV second index MRV_2 will become 1. So, the MRV first index MRV_1 will be the index value MRV.

As a result, the vertical moire index value MRV thus determined can show the vertical moire level in the vertical direction.

In Step S**54**, the MRH detection unit **81** calculates the moire in the horizontal direction, i.e., the horizontal moire index value MRH showing a horizontal moire level about the respective pixels of the input image signal normalized, and output the horizontal moire index value MRH to the mixed processing unit **83**. The processing in the MRH detection unit **81** is similar to that in the MRV detection unit **82** except that the pixel columns to be processed is rotated 90 degrees, and therefore a description thereof will be omitted.

In Step S**55**, the mixed processing unit **83** mixes the vertical moire index value MRF fed from the MRV detection unit **82** and the horizontal moire index value MRH fed from the MRH detection unit **81** in each pixel based on a ratio fed from the HV correlation detection unit **65** and feeds it to the LPF **63** as the horizontal and vertical moire index value MRHV.

In Step S**56**, the LPF **63** performs a low pass filter processing on the horizontal and vertical moire index value MRHV fed from the mixed processing unit **83** in each pixel using the filter shown in the right side of FIG. **4**, and outputs the horizontal and vertical moire index value MRHV to the modulation unit **64**.

In Step S**57**, the modulation unit **64** performs a modulation processing on the horizontal and vertical moire index value MRHV to which the low pass filter processing is performed in each pixel to decrease a high detection value and outputs the horizontal and vertical moire index value MRHV to the mixed processing unit **42**.

In other words, the horizontal and vertical moire index value MRHV showing the moire level in the horizontal and vertical directions in each pixel is determined by the horizontal and vertical moire detection processing described by referring to the flow chart in FIG. **10**, and is fed to the mixed processing unit **42**. As the horizontal and vertical moire index value MRHV determined here has a value of 0 or 1, which can be used as it is as the mixing ratio with the HV moire cancellation image signal.

Here, it returns to the description of the flow chart in FIG. **6**.

In Step S**16**, the HV LPF **32** is the filter for cancelling the moire in the horizontal and vertical directions from each pixel of the input image signal as shown at a left side of FIG. **3**, for example, and generates and outputs the HV moire cancellation image signal to the mixed processing unit **42**.

In Step S**17**, the mixed processing unit **42** mixes each pixel of the primary moire suppression image signal outputted from the mixed processing unit **41** and each pixel of the HV moire cancellation image signal at a mixing ratio based on the horizontal and vertical moire index value supplied from the modulation unit **64** and generates and outputs an output image signal.

Through the above-described processing, the oblique moire cancellation image signal and the horizontal and vertical moire cancellation image signal can be mixed to the input image at a ratio corresponding to the oblique moire index value showing the oblique moire level and to the horizontal and vertical moire index value showing the extent of the horizontal and vertical moire. As a result, a decrease in a resolution and color bleeding caused by utilizing an oblique moire cancellation image and a horizontal and vertical moire cancellation image without change can be prevented, while a false color can be prevented from generating caused by color moire.

In the above illustrative description, the normalization unit **61** is used for preprocessing (Steps S**51** and S**51** in FIG. **10**) of the horizontal and vertical moire index value detection processing. As the experiment reveals that the similar results can be provided even if the normalization unit **61** is omitted, the normalization unit **61** may be omitted as necessary.

In the above illustrative description, the primary moire suppression image signal is generated by mixing the oblique moire cancellation image signal at the mixing ratio based on the oblique moire index value to the input image signal. Thereafter, the primary moire suppression image signal is mixed with the horizontal and vertical moire cancellation image signal at a mixing ratio based on the horizontal and vertical moire index value.

However, the remarkable effects can be achieved by mixing the input image with the oblique moire cancellation image signal based on the oblique moire index value and with the horizontal and vertical moire cancellation image signal based on the horizontal and vertical moire index value. The order of mixing the input image with the input image with the oblique moire cancellation image signal and the horizontal and vertical moire cancellation image signal may be interchanged.

Furthermore, in the above illustrative description, although the oblique moire utilizes the periodicity in 45 degrees and 135 degrees in the horizontal direction, any other angular periodicity may be utilized.

A series of the above-describe processing may be performed by hardware but may be performed by software. When a series of the processing is performed by software, a program of the software is installed from a recoding medium to a computer incorporated into dedicated hardware or a general purpose personal computer being capable of executing a variety of functions by installing a variety of programs.

FIG. **13** shows an illustrative configuration of a general purpose personal computer. A CPU (Central Processing Unit) **1001** is built in the personal computer. An input output interface **1005** is connected to the CPU **1001** via a bus **1004**. A ROM (Read Only Memory) **1002** and a RAM (Random Access Memory) **1003** are connected to the bus **1004**.

An input unit **1006** including an input device such as a keyboard and a mouse for inputting an operation command by a user, an output unit **1007** for outputting a processing operation screen and a processing result image to the display device, a storing unit **1008** including a hard disk drive for storing a program and a variety of data, and a communication unit **1009** including a LAN (Local Area Network) adapter and executing communication processing via a network such as Internet are connected to the input output interface **1005**. Also, a drive **1010** for reading and writing data to a removable recording medium **1011** such as a magnetic disc (including flexible disc), an optical disc (CD-ROM (Compact Disc-Read Only Memory), DVD (Digital Versatile Disc), a magnetooptical disc (including MD (Mini Disc) and a semiconductor memory are connected thereto.

The CPU **1001** executes a variety of processing in accordance with a program stored in the ROM **1002** or a program that is read out from the removable recording medium **1011** such as the magnetic disc, the optical disc, magnetooptical disc and a semiconductor memory, installed to the storing unit **1008** and loaded from the storing unit **1008** to the RAM **1003**. Data necessary to execute a variety of processing by the CPU **1001** is also stored, as appropriate.

In the computer configured as described above, the CPU **1001** loads the program stored in the storing unit **1008** to the RAM **1003** via the input output interface **1005** and the bus **1004** and executes the program, thereby performing a series of processing as described above.

The program executed by the computer (CPU **1001**) can be provided by storing in the removable recording medium **1011** such as a package medium. Also, the program can be provided via a wired or wireless transmission medium such as a local area network, an internet and a digital satellite broadcasting.

In the computer, the program can be installed to the storing unit **1008** via the input output interface **1008** by mounting the removable recording medium **1011** to the drive **1010**. Also, the program can be received at the communication unit **1009** via the wired or wireless transmission medium and installed to the storing unit **1008**. In addition, the program can be installed to the ROM **1002** or the storing unit **1008** in advance.

Note that the program executed by the computer may be processed in time series along the sequence described in the specification or may be processed in parallel or at a necessary timing of invoking.

In the context of the specification, the system means an assemblage of a plurality of components (apparatuses, modules (parts)). Whether or not all components are included in the same housing does not matter. Accordingly, any of a plurality of apparatuses housed in separate housings and connected via the network and one apparatus where a plurality of modules are housed in one housing is the system.

It should be understood that the present technology is not limited to the above described embodiments and that various changes may be made without departing from the scope of the present technology.

For example, according to an embodiment of the present technology, a cloud computing where one function is shared and commonly processed by a plurality of apparatuses via a network may be used.

Each step described in the above-described flow charts can be executed by one apparatus, or can be shared and executed by a plurality of apparatuses.

A plurality of processes included in one step can be executed by one apparatus or can be shared and executed by a plurality of apparatuses.

The present technology may have the following configurations.

(1) An image processing apparatus, including:

a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array;

a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and

a moire suppression unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit.

(2) The image processing apparatus according to (1) above, in which

the direction detection unit detects a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction,

the moire detection unit includes

a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction;

a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and

a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and

outputs the moire index value generated by the mixed processing unit as a detection result.

(3) The image processing apparatus according to (2) above, further including:

a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image,

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value.

(4) The image processing apparatus according to (3) above, in which

the horizontal and vertical moire reduced image generation unit is a filter having a low pass property in a horizontal direction and a vertical direction to each pixel of the input image.

(5) The image processing apparatus according to (1) above, further including:

an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and

an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value,

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

(6) The image processing apparatus according to (5) above, in which

the oblique moire detection unit includes

an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction;

an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and

a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and

outputs the oblique moire index value detected by the maximum value detection unit as a detection result.

(7) The image processing apparatus according to (5) above, in which

the oblique moire reduced image generation unit is a filter having a low pass property in the oblique direction to each pixel of the input image.

(8) The image processing apparatus according to (1) above, further including:

a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image, an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and

an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value,

the direction detection unit detects a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction,

the moire detection unit includes

a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction;

a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and

a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and

outputs the moire index value generated by the mixed processing unit as a detection result,

the oblique moire detection unit includes

an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction;

an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and

a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and

outputs the oblique moire index value detected by the maximum value detection unit as a detection result, and

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value to generate a primary moire suppression image, and by mixing the primary moire suppression image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

(9) The image processing apparatus according to (1) above, in which

the color pixel array is a Bayer array.

(10) A method of processing an image, including:

detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array;

detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and

suppressing the moire level in the input image based on the moire index value detected.

(11) A program for causing a computer to execute a method of:

detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array;

detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value; and

suppressing the moire level in the input image based on the moire index value detected.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. An image processing apparatus, comprising:

a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array;

a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value;

a moire suppression unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit,

the direction detection unit detects a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction,

the moire detection unit includes:

a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction;

a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and

a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and output the moire index value generated by the mixed processing unit as a detection result; and

a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image,

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value.

2. The image processing apparatus according to claim **1**, wherein

the horizontal and vertical moire reduced image generation unit is a filter having a low pass property in a horizontal direction and a vertical direction to each pixel of the input image.

3. The image processing apparatus according to claim **1**, wherein

the color pixel array is a Bayer array.

4. A method of processing an image, comprising:

detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array;

detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value;

suppressing the moire level in the input image based on the moire index value detected;

generating an oblique moire reduced image by reducing the moire in an oblique direction from the input image;

detecting a moire level in the oblique direction in the input image as an oblique moire index value; and

suppressing a moire level in the input image by mixing the input image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

5. The method according to claim 4, wherein

the generating of the oblique moire reduced image by reducing the moire in an oblique direction from the input image utilizes a filter having a low pass property in the oblique direction to each pixel of the input image.

6. A non-transitory computer readable storage medium having stored thereon, a set of computer-executable instructions for causing a computer to execute steps comprising:

detecting a direction of a picture pattern of each pixel in an input image having a predetermined color pixel array;

detecting a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value;

suppressing the moire level in the input image based on the moire index value detected;

generating an oblique moire reduced image by reducing the moire in an oblique direction from the input image;

detecting a moire level in the oblique direction in the input image as an oblique moire index value; and

suppressing a moire level in the input image by mixing the input image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

7. The non-transitory computer readable storage medium according to claim 6, wherein

the generating of the oblique moire reduced image by reducing the moire in an oblique direction from the input image utilizes a filter having a low pass property in the oblique direction to each pixel of the input image.

8. An image processing apparatus, comprising:

a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array;

a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value;

a moire suppression unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit;

an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and

an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value,

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

9. The image processing apparatus according to claim 8, wherein the oblique moire detection unit includes:

an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction;

an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and

a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and outputs the oblique moire index value detected by the maximum value detection unit as a detection result.

10. The image processing apparatus according to claim 8, wherein the oblique moire reduced image generation unit is a filter having a low pass property in the oblique direction to each pixel of the input image.

11. An image processing apparatus, comprising:

a direction detection unit configured to detect a direction of a picture pattern of each picture in an input image having a predetermined color pixel array;

a moire detection unit configured to detect a moire level by periodicity of a pixel value of each pixel in the input image depending on the direction as a moire index value;

a moire suppression unit configured to suppress the moire level in the input image based on the moire index value detected by the moire detection unit;

a horizontal and vertical moire reduced image generation unit configured to generate a horizontal and vertical moire reduced image by reducing the moire in the horizontal direction and the vertical direction from the input image;

an oblique moire reduced image generation unit configured to generate an oblique moire reduced image by reducing the moire in an oblique direction from the input image; and

an oblique moire detection unit configured to detect a moire level in the oblique direction in the input image as an oblique moire index value,

the direction detection unit detects a direction of the picture pattern as a directional correlation value to a horizontal direction and a vertical direction,

the moire detection unit includes:

a horizontal moire detection unit configured to detect a horizontal moire index value that is a moire index value in a horizontal direction;

a vertical moire detection unit configured to detect a vertical moire index value that is a moire index value in a vertical direction; and

a mixed processing unit configured to mix the horizontal moire index value and the vertical moire index value depending on the directional correlation value to generate the moire index value, and outputs the moire index value generated by the mixed processing unit as a detection result,

the oblique moire detection unit includes:

an oblique 45 degree moire detection unit configured to detect an oblique 45 degree moire index value that is a moire index value in an oblique 45 degree direction;

an oblique 135 degree moire detection unit configured to detect an oblique 135 degree moire index value that is a moire index value in an oblique 135 degree direction; and

a maximum value detection unit configured to detect a maximum value of the oblique 45 degree moire index value and the oblique 135 degree moire index value as the oblique moire index value, and outputs the oblique moire index value detected by the maximum value detection unit as a detection result, and

the moire suppression unit suppressing a moire level in the input image by mixing the input image and the horizontal and vertical moire reduced image at a mixing ratio based on the moire index value to generate a primary moire suppression image, and by mixing the primary moire suppression image and the oblique moire reduced image at a mixing ratio based on the oblique moire index value.

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